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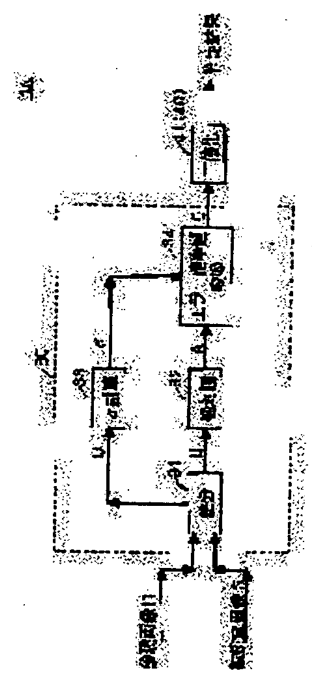
(54) PATTERN INSPECTION SYSTEM

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a pattern inspection system in which the defect of an image to be inspected can be detected while taking account of the effect of a noise component.

SOLUTION: A pattern inspection system 1A generates a difference image U between an image to be inspected S and a reference image R and converts the pixel value of each pixel in the difference image U into an error probability value Er using a standard deviation σ concerning to the pixel value of the difference image U. An absolute value image A generated based on the difference image U is used in the conversion. The error probability value Er thus obtained represents the degree of defect concerning to each pixel of the image to be inspected S and a decision is made whether a defect of an object to be inspected is presents or not at a position corresponding to each pixel of the image to be inspected S based on the relation of magnitude between the error probability value Er and a specified threshold value.



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CLAIMS

[Claim(s)]

[Claim 1] Pattern test equipment which conducts defective inspection of a pattern by comparing the inspected picture and reference picture which are characteriz d by providing the following. An inspected picture acquisition means to acquire th inspected picture about an inspected object. A reference picture acquisition means to acquire the reference picture set as the comparison object of the aforementioned inspected picture, Generate the difference fractionation image between the aforementioned reference picture and the aforementioned inspected picture, and the pixel value of each pixel in the difference fractionation image concerned using the standard deviation about the pixel value of the difference fractionation image concerned A defective degree acquisition means to acquire the defective degree about each pixel of the aforementioned inspected picture by changing into the error probability value as what standardized each pixel value according to the distributed situation of the pixel value in the aforementioned difference fractionation image.

[Claim 2] In pattern test equipment according to claim 1 the aforementioned reference picture acquisition means Two or more reference pictures are acquir d. the aforementioned defective degree acquisition means Two or more difference fractionation images between each of two or more aforementioned reference pictures and the aforementioned inspected picture are generated. being concerned -- each -- difference -- the standard deviation about the pixel value of a picture -- using -- being concerned -- each -- difference -- the pixel value of each pixel in a picture -- an error probability value -- changing -- the difference of further the aforementioned plurality -- by asking for the product of the error probability value of a correspondence pixel covering a picture Pattern test equipment characterized by acquiring the defective degree about each pixel of the aforementioned inspected picture.

[Claim 3] In pattern test equipment according to claim 2 the aforementioned inspected object It has a repeat pattern. the aforementioned inspected picture acquisition means The picture about one unit pattern of the afor mentioned repeat pattern contained in the image pck-up picture about the aforementioned inspected object is acquired as an inspected picture. the aforemention d r f rence picture acquisition means Pattern test equipment characterized by acquiring each picture about two or more unit patterns other than the aforementioned inspected picture

included in the aforementioned image pck-up picture as two or more aforementioned reference pictures.

[Claim 4] In pattern test equipment according to claim 1 the aforementioned inspected picture acquisition means Two or more inspected pictures about the same inspected field in the aforementioned insp cted object are acquired. the aforementioned defectiv degree acquisition means Two or more difference fractionation images between each of two or more aforementioned inspected pictures and the aforementioned reference picture are generated. being concerned -- each -- difference -- the standard deviation about the pixel value of a picture -- using -- being concerned -- each -- difference -- the pixel value of each pixel in a picture -- an error probability value -- changing -- the difference of furth r the aforementioned plurality -- by asking for the product of the error probability value of a correspondence pixel covering a picture Pattern test equipment characterized by acquiring the defective degree about each pixel of the aforementioned inspected picture.

[Claim 5] Pattern test equipment characterized by having further a judgment means to judge the existence of the defect of the inspected object in the position corresponding to each pixel of the aforementioned inspected picture in pattern test equipment according to claim 1 to 4 based on the size relation between th defective degree obtained by the aforementioned defective degree acquisition means, and a predetermined threshold.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to pattern test equipment applicable to the pattern-defect inspection in a light filter, a shadow mask, a printed wired board, a semiconductor wafer, etc.
[0002]
[Description of the Prior Art] In the objects (for example, a light filter, a shadow mask, a printed wired board, a semiconductor wafer, etc.) to be examined which have a pattern, in order to detect the defect which exists in the pattern, the technology detect the existence of the defect exists by using the difference fractionation image of an inspected picture and a reference picture using the reference picture as an ideal pattern to the picture (it is hereafter called an "inspected picture") of the field of the object to be examined to be examined.
[0003] such technology -- setting -- difference -- binarization of the concentration value (difference concentration value) in a picture is carried out using a predetermined threshold -- the existence of a defect is judged by things
[0004]
[Problem(s) to be Solved by the Invention] however, in the above-mentioned technology, since the influence of the noise component contained in an inspected picture is not taken into consideration, the threshold for the defective judging is set up appropriately -- things have the problem of being difficult
[0005] Drawing 14 is drawing showing two examples (a) about the distribution about the pixel value of two or more pixels contained in a difference fractionation image, and (b). each example -- setting -- a horizontal axis -- difference -- the pixel value (difference concentration value) of each pixel in Picture U -- expressing -- a vertical axis -- each -- difference -- the number of the pixels which have a concentration value (the number of distribution pixels) is expressed. Drawing 14 (a) is a graph about a difference fractionation image with many noise components, and drawing 14 (b) is a graph about a difference fractionation image with f w noise components.
[0006] for example, it is shown in this drawing 14 -- as -- difference with many the noise component -- difference with few pictures (a) and noise components -- although an exact defective judging is possible in one case when it is any of a picture (b) and the same threshold is defined -- the case of another side --

setting -- misjudgment -- a law may be performed That is, when the optimal threshold Vb to th difference fractionation image of drawing 14 (b) is used for the difference fractionation image of drawing 14 (a), as shown in drawing 14 (a), it may carry out a misjudgment law, using a noise component as a def ct. Moreover, conversely, if the optimal threshold Va to the difference fractionation image of drawing 14 (a) is used for the difference fractionation image of drawing 14 (b), an original defective component may be undetectable as a defect.

[0007] Moreover, when a threshold separate about each case was defined, it also had the problem that it was very difficult by what criteria to define the suitable threshold.

[0008] Then, this invention aims at offering the pattern test equipment which can perform defective detection in the inspected picture in consideration of the influence of a noise component etc. in view of the aforementioned trouble.

[0009]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, invention according to claim 1 An inspected picture acquisition means to be pattern test equipment which conducts defective inspection of a pattern by comparing an inspected picture with a reference picture, and to acquire the inspected picture about an inspected object, A reference picture acquisition means to acquire the reference picture set as the comparison object of the aforementioned inspected picture, Generate the difference fractionation image between the aforementioned reference picture and the aforementioned inspected picture, and the pixel value of each pixel in the difference fractionation image concerned using the standard deviation about the pixel value of the difference fractionation image concerned By changing into the error probability value as what standardized each pixel value according to the distributed situation of the pixel value in the aforementioned difference fractionation image, it is characterized by having a defective degree acquisition means to acquire the defective degree about each pixel of the aforementioned inspected picture.

[0010] Invention according to claim 2 is set to pattern test equipment according to claim 1. the aforementioned reference picture acquisition means Two or more reference pictures are acquired. the aforementioned defective degree acquisition m ans Two or more difference fractionation images between each of two or more aforementioned reference pictures and the aforementioned inspected picture are generated. being concerned -- each -- difference -- the standard deviation about the pixel value of a picture -- using -- being concerned -- each -- difference -- the pixel value of each pixel in a picture -- an error probability value -- changing -- the difference of further the aforementioned plurality -- by asking for the product of the error probability value of a correspondence pixel covering a picture It is characterized by acquiring the defective degree about each pixel of the aforementioned inspected picture.

[0011] Invention according to claim 3 is set to patt rn test quipment according to claim 2. the aforementioned inspected object It has a repeat pattern. the aforementioned inspected picture acquisition means The picture about one unit pattern of the aforementioned rep at pattern contain d in the image pck-up picture about the aforementioned inspected object is acquired as an inspect d

picture. the aforem ntioned r ference picture acquisition means It is characteriz d by acquiring ach pictur about two or more unit patterns oth r than the aforementioned inspected picture included in th aforementioned image pck-up picture as two or more aforementioned reference pictures.

[0012] Invention according to claim 4 is set to pattern test equipment according to claim 1. the aforementioned inspected picture acquisition means Two or more inspected pictures about the same inspected field in the aforementioned inspect d object are acquired. the aforementioned defective degree acquisition means Two or more difference fractionation images between each of two or more aforementioned inspected pictures and the aforementioned reference picture ar generated. being concerned -- each -- difference -- the standard deviation about the pixel value of a picture -- using -- being concerned -- each -- difference -- the pixel value of each pixel in a picture -- an error probability value -- changing -- the difference of further the aforementioned plurality -- by asking for the product of the error probability value of a correspondence pixel covering a picture It is characterized by acquiring the defective degree about each pixel of the aforementioned inspected picture.

[0013] Invention according to claim 5 is characterized by having further a judgment means to judge the existence of the defect of the inspected object in the position corresponding to each pixel of the aforementioned inspected picture, based on the size relation between the defective degree obtained by the aforementioned defective degree acquisition means, and a predetermined threshold in pattern test equipment according to claim 1 to 4.

[0014]

[Embodiments of the Invention] <A. 1st operation gestalt> drawing 1 is a schematic diagram showing the composition of the pattern test equipment 1 (1A) concerning the 1st operation gestalt of this invention. Pattern test equipment 1A is equipp d with X-Y table 3 which lays the object (inspected object) 2 used as a subject of examination, the mechanical component 4 containing the motors 4a and 4b which drive X-Y table 3 in the direction of X, and the direction of Y, respectively, and the CCD line sensor 5 which picturizes the inspected object 2. Here, the plan which expresses the detail to drawing 2 is shown supposing the case where the semiconductor wafer W is inspected as an inspected object 2. As shown in drawing 2 , the semiconductor wafer W has the structure where "die (die)" 2a which is two or more unit patterns is arranged in the shape of a repeat matrix in the direction of X, and the direction of Y, respectively.

[0015] Moreover, the inspected picture acquisition section 10 from which pattern test equipment 1A acquires the inspected picture S about the inspected object 2, The reference picture acquisition section 20 which acquires the reference pictur R set as the comparison object of the inspected picture S, the difference between the reference picture R and the inspected picture S -- Picture U -- generating -- th difference concerned -- the standard deviation about the pixel value of Picture U -- using -- the difference concerned -- by changing the pixel value of ach pixel in Picture U into an error probability value (it mentioning later) The defective degree acquisition section 30 which acquires the defective degree about each pixel of the inspected picture S, It has the defective judging s ction 40 which

judges the existence of the defect of the inspected object 2 in the position corresponding to each pix l of the inspected picture S based on the size relation between the defective degree obtained by the def ctive degree acquisition section 30 and a predetermined threshold.

[0016] Here, the inspected picture acquisition section 10 performs processing which acquires one unit pattern contained in the image pck-up picture about the inspected object 2 acquired through the CCD line sensor 5 as an inspected picture.

[0017] Specifically, with movement of the direction (-) of Y of X-Y table 3, the CCD line sensor 5 moves in the direction (+) of Y relatively to the inspected object 2, and scans the inspected object 2 top by constant speed in the direction (+) of Y. By the scan of such a direction of Y, the picture (it is hereafter called an "image pck-up picture") which picturized the inspected object 2 can be acquired. And one arbitrary unit pattern in two or more unit patterns contained in this image pck-up picture is acquired by the inspected picture acquisition section 10 as an inspected picture S. Thus, the below-mentioned pattern inspection operation is performed about the acquired inspected picture S.

[0018] Then, the CCD line sensor 5 can acquire the same inspected picture S also by moving in the direction (-) of Y relatively, and scanning, after only predetermined width of face (for example, width of face xa) moves in the direction of X (+) relatively to the inspected object 2. Furthermore, by repeating successively move operation of the direction of X (+), and scanning operation to the direction (+, -) of Y, the same inspected picture S is acquired, and pattern inspection operation can be repeated and can be performed.

[0019] Moreover, the reference picture acquisition section 20 acquires the reference picture R set as the comparison object of the inspected picture S. The data of an ideal unit pattern are acquirable, using CAD data etc. as this reference picture R.

[0020] Drawing 3 is the functional block diagram of the defective degree acquisition section 30 and the defective judging section 40. the defective degre acquisition section 30 -- difference -- it has the processing section 31, the absolute value calculation processing section 32, sigma calculation section 33, and the error probability value transducer 34 Moreover, the defective judging section 40 has the binarization processing section 41.

[0021] The composition and operation of these defective degree acquisition sections 30 and the defective judging section 40 are explained referring to drawing 3 . In addition, before shifting to operation by these defective degree acquisition sections 30 and the defective judging section 40, as it mentioned above, the inspected picture S shall be acquired by the inspected picture acquisition section 10, and the reference picture R shall be acquired by the reference picture acquisition section 20.

[0022] first, difference -- the processing section 31 -- th diff rence between the reference picture R and the inspected picture S -- Picture U is gen rated the difference of th pixel value of each pixel which specifically exists in the position which corresponds in both the pictures R and S -- computing a valu (diff rence concentration value) -- difference -- Picture U is generated

[0023] moreover, th absolute value calculation processing section 32 -- difference -- the difference generated by the proc ssing section 31 -- processing which computes the absolute value picture A based on Picture U is performed The absolute value picture A used in the error probability value transduc r 34 by this absolute value calculation processing section 32 is generable beforehand.
[0024] furthermore, sigma calculation section 33 -- difference -- the difference generated by the processing section 31 -- the standard deviation sigma about th pixel value of Picture U is computed Specifically, about two or more pixels (for example, all pixels) contained in the difference fractionation image U, statistics processing about the pixel value is performed, and it asks for standard deviation sigma. This standard deviation sigma is used in the error probability value transducer 34.
[0025] And the error probability value transducer 34 acquires the defective degree about each pixel of the inspected picture S by acquiring the error probability value picture E which changed the pixel value of each pixel in the difference fractionation image U into the error probability value Er using the standard deviation sigma computed in sigma calculation section 33. The pixel value (namely, error probability value Er) of each pixel of this error probability value picture E will express a "defective degree."
[0026] Each pixel is an index value showing the degree which is a true defect, and this "defective degree" can also be expressed as the "defective criticality" showing the criticality of the pixel defect. In addition, although the case where it computes indirectly using the absolute value picture A generated from the difference fractionation image U is illustrated in computing an error probability value by the error probability value transducer 34, it is not limited to this but you may compute here, using directly the pixel value of each pixel in the difference fractionation image U.
[0027] Specifically according to the following several 1, the pixel value (concentration value) i of each pixel of the absolute value picture A is changed into the error probability value Er (i).
[0028]
[Equation 1]

$$Er(i)=\frac{i}{C\times\sigma}$$

$$\left(\begin{array}{l}\text{但し、}Er(i)\text{が}1.0\text{を越えた場合、}\\ \quad Er(i)=1.0\text{とする。}\end{array}\right)$$

[0029] here -- i -- the pixel value (the following and "-- difference -- it is also called absolute concentration value") of each pixel of the absolute value picture A, and sigma -- difference -- the standard deviation of a picture, and c -- a parameter coefficient and Er (i) -- difference -- the error probability value of the absolute concentration value i is expressed
[0030] moreov r, drawing 4 -- differ nce -- it is drawing showing the transform function which performs conversion to the error probability value Er from th absolute concentration value i drawing 4 -- setting -- a horizontal axis -- difference -- expressing the absolute concentration value i, the v rtical axis

expresses the error probability value Er it is shown in this drawing 4 -- as -- the difference of the predet rmined range -- the absolute concentration value i and the error probability value Er are matched in the state with linear relation up to th value (cxsigma) which in other words multiplied the parameter coefficient c by standard deviation sigma from 0 (zero) -- each -- difference -- the absolute concentration value i is matched with each error probability value Er from 0.0 to 1.0

[0031] the difference which the parameter coefficient c is a parameter which performs a range comprehension here, and has a value (cxsigma) -- it is standardized so that the absolute concentration value i may be matched with th maximum (1.0) of the error probability value Er adjusting this parameter coefficient c -- difference -- the correspondence relation between the absolute concentration value i and the error probability value Er can be specified more appropriately For example, when it can be assumed that a pixel distribution is a normal distribution, and the integration value of the probability density function from the value (- cxsigma) in a normal distribution to a value (cxsigma) is c= 3, it is possible to choose the value of c=2-4 95.44% corresponding to 99.9999% and a bird clapper at the time of c= 4 etc.

[0032] in addition, this difference -- conversion operation to the error probability value Er from the absolute concentration value i -- difference -- it is also possible to perform relation between the absolute concentration value i and the error probability value Er based on the look-up table (LUT) stored beforehand

[0033] It can be said that each computed error probability value Er is an index value showing the defective degree about each pixel of an inspected picture, and standardizes the pixel value (here difference the absolute concentration value i) of each pixel of the difference fractionation image U using the standard deviation sigma reflecting the distributed situation of the pixel value of the difference fractionation image U (or standardization). According to this error probability valu Er, it is possible to equalize dispersion by the noise component contained in th difference fractionation image U, and to perform unific treatment. That is, unific treatment becomes possible irrespective of some of noise components by judging a defect using the error probability value Er.

[0034] Moreover, the binarization processing section 41 is the processing section which carries out binarization of the error probability value Er showing the defective degree acquired in the defective degree acquisition section 30 about whether it is a defect according to the comparison result of the size judging in comparison with the predetermined threshold. Thereby, the existence of the defect of the inspected object 2 in the position corresponding to each pixel of the inspected picture S can be judged.

[0035] Drawing 5 (a), (b), and (c) are drawings showing the statistical distribution about the pixel value of two or more pixels contained in the difference fractionation image U. among these, drawing 5 (a) and (b) -- setting -- a horizontal axis -- diff r nce -- the pixel value (difference concentration value) of each pixel in Picture U -- expressing -- a vertical axis -- each -- difference -- the number of the pixels which have a concentration value (th number of distribution pix ls) is expressed in addition -- this drawing -- difference -- not an absolute

concentration value but difference -- although expressed using the concentration value -- difference -- what is necessary is to add the left-hand side half of each graph to a right-hand sid half, and just to argue about it, wh n an absolut concentration value discusses Moreover, drawing 5 (a) is a graph about a difference fractionation image with many noise components, and drawing 5 (b) is a graph about a difference fractionation image with few noise components. In addition, drawing 5 (a) and drawing 5 (b) are drawings which express the same state as drawing 14 (a) and drawing 14 (b), respectively.

[0036] And when there are many noise components (drawing 5 (a)), the distribution curves of the pixel about the difference fractionation image U are any when there are few noise components (drawing 5 (b)) and they are expressed with the distribution curve (for example, normal distribution) of the same kind, it sets. ach -- difference -- if the absolute concentration value i is changed into the error probability value Er, as shown in drawing 5 (c), any [of drawing 5 (a) and drawing 5 (b)] graph of a case will be standardized by the same (theoretically) distribution curve drawing 5 (c) -- setting -- a vertical axis -- the above (a) and (b) -- the same -- each -- difference -- although the number of the pixels which have a concentration value (the number of distribution pixels) is expressed -- a horizontal axis -- difference -- the absolute concentration value i -- replacing -- differ nc -- the error probability value Er of each pixel in Picture U is expressed Thus, when there are many noise components, and there are few (a) and noise components and it is any of (b), it can treat to treat in the same graph (c), i.e., a unification target. thus, the conversion to this error probability value Er -- difference -- it is equivalent to standardizing the absolute concentration value i

[0037] Therefore, since a suitable threshold can be more easily set up by adding statistical consideration to the error probability value Er standardized using standard deviation sigma, it becomes possible to set up appropriately the threshold used for a defective judging in consideration of the influence of the noise component contained in the inspected picture S. That is, when there are many noise components, and there are few (a) and noise components and it is any of (b), the same threshold to the error probability value Er can perform a suitable defective judging.

[0038] as mentioned above -- according to pattern test equipment 1A of this 1st operation gestalt -- the difference between the reference picture R and the inspected picture S -- Picture U -- generating -- the difference concerned -- the standard deviation sigma about the pixel value of Picture U -- using -- the difference concerned -- the defective degree about each pixel of the inspected picture S is acquirable by changing the pixel value of each pixel in Picture U into the error probability value Er Therefore, objective evaluation can be easily performed by obtaining the index generalized using standard deviation in evaluating a defective degree. Moreover, the existence of the defect of each pixel in the difference fractionation image U can be more appropriately judged by asking for a size relation with the threshold defined appropriately about the defective degree expr ssed with this error probability valu Er. In here, since th above-mentioned error probability value Er is standardized, it becom s easy to determin a predetermined threshold appropriately.

[0039] Although the single reference picture R set as the comparison object of the inspected picture S was acquired in th r ference picture acquisition section 20 in the 1st operation gestalt of the <B. 2nd operation g stalt> above and comparison with this single reference picture R and th inspected picture S explained the case where the d fective judging of the inspected picture S was performed In this 2nd operation gestalt, the case where the defective judging of the inspected picture S is performed using two or more reference pictures R is explained.

[0040] The pattern test equipment 1 (1B) concerning the 2nd operation gestalt has the 1st operation gestalt and analogous composition, and, below, mainly explains them focusing on difference.

[0041] In this 2nd operation gestalt, the inspected object which has a repeat pattern is picturized by the CCD line sensor 5. The picture about one arbitrary unit pattern in two or more unit patterns contained in the image pck-up picture is acquired as an inspected picture S by the inspected picture acquisition section 10. The case where the picture about each of two or more unit patterns other than the inspected picture S is acquired as two or more reference pictures R by the reference picture acquisition section 20 is explained. Specifically, as shown in drawing 2 , the case where acquire the picture about the unit pattern PB as an inspected picture S among two or more unit patterns arranged in the direction of Y of the inspected object 2 (semiconductor wafer W) which has a repeat pattern, and each of the picture about two unit patterns PA and PC is acquired as a reference picture R is explained.

[0042] Drawing 6 is the functional block diagram of the defective degree acquisition section 30 (30B) concerning the 2nd operation gestalt, and the defective judging section 40 (40B). defective degree acquisition section 30B — difference — it has the processing sections 31a and 31b, the absolute value calculation processing sections 32a and 32b, sigma calculation sections 33a and 33b, the error probability value transducers 34a and 34b, and the addition section 35 Moreover, the defective judging section 40 has the binarization processing section 41.

[0043] The composition and operation of such defective degree acquisition section 30B and defective judging section 40B are explained referring to drawing 6 . In addition, before shifting to operation by such defective degree acquisition section 30B and defective judging section 40B, the inspected picture S shall be acquired by the inspected picture acquisition section 10 as mentioned above, and the reference picture R of plurality (here two) shall be acquired by the reference picture acquisition section 20.

[0044] Drawing 7 (a) - (c) is drawing having shown typically the pixel value of the pixel of each picture about the unit patterns PA, PB, and PC, and is shown as that by which the pixel value of some each of the pixels is arranged in one dimension for simplification, respectively. Moreover, drawing 8 to drawing 11 is drawing showing typically the processing result in each below-mentioned processing using each picture about each of these unit patterns PA, PB, and PC. In addition, the case where these true defects are d tect d appropriately as a defective pixel is illustrated about the case where the 3rd and the 11th pixel are true def cts here.

[0045] first, difference — processing section 31a — the difference b tween the

r ference picture R (picture about the unit pattern PA), and the inspected pictur S (picture about the unit pattern PB) -- Picture U is generated the difference of the pixel value of each pixel which specifically exists in the position which corresponds in both the pictures R and S -- computing a concentration value -- difference -- picture U (AB) is generated the same -- difference -- processing s ction 31b -- the difference between the reference picture R (unit pattern PC) and the inspected picture S (unit pattern PB) -- picture U (BC) is generated

[0046] moreover, absolute value calculation processing section 32a -- difference -- the difference generated by processing section 31a -- processing which computes absolute value picture A (AB) based on picture U (AB) is performed the same -- absolute value calculation processing section 32b -- difference -- the difference generated by processing section 31b -- processing which computes absolute value picture A (BC) based on picture U (BC) is performed

[0047] Drawing 8 is drawing showing typically the pixel value of each pixel of the absolute value picture A acquired by doing in this way. Drawing 8 (a) expresses absolute value picture A (AB), and drawing 8 (b) expresses absolute value picture A (BC).

[0048] furthermore, sigma calculation section 33a -- difference -- the difference generated by processing section 31a -- standard deviation sigma (AB) about the pixel value of picture U (AB) -- computing -- sigma calculation section 33b -- difference -- the difference generated by processing section 31b -- standard deviation sigma (BC) about the pixel value of picture U (BC) is computed

[0049] And error probability value transducer 34a obtains error probability valu picture E (AB) which changed the pixel value of each pixel in absolute value picture A (AB) into the error probability value Er using standard deviation sigma (AB) computed in sigma calculation section 33a. Similarly, error probability value transducer 34b obtains error probability value picture E (BC) which changed the pixel value of each pixel in absolute value picture A (BC) into the error probability value Er using standard deviation sigma (BC) computed in sigma calculation s ction 33b. Also about this conversion operation, it is the same as that of the above-mentioned 1st operation gestalt, and can perform performing conversion operation based on the transformation expressed with relations, such as several 1, etc.

[0050] Drawing 9 is drawing showing typically the pixel value of each pixel of th error probability value picture E acquired by doing in this way. Drawing 9 (a) expresses error probability value picture E (AB), and drawing 9 (b) expresses error probability value picture E (BC).

[0051] Furthermore, the addition section 35 searches for the addition picture EP based on error probability value picture E (AB) obtained in the above, and error probability value picture E (BC). Specifically, the pixel value of each pixel of the addition picture EP is calculated by integrating the pixel value of each correspondence pixels of error probability value pictur E (AB) and error probability value picture E (BC). However, in order to become common more here, as shown in several 2, it is asking for the geometrical mean.

[0052]

[Equation 2]

$$EP=\sqrt{E(AB)\times E(BC)}$$

[0053] In addition, although sign E (AB), E (BC), and EP are signs used as what originally expresses the whole picture, they shall synthesize and write the case where the pixel value is calculated for each [of each error probability value picture E (AB) E (BC), and the addition picture EP] pixel of every, in several 2. Moreov r, what is necessary is just to ask for the n-th root of the integrated value of th correspondence pixel in n error probability value pictures E as a pixel value of each pixel of the addition picture EP, in searching for the addition picture EP using n error probability value pictures E, although here explained the case where the addition picture EP was searched for using two error probability value pictures E.
[0054] In this 2nd operation gestalt, the pixel value of each pixel of the addition picture EP acquired by doing in this way expresses the defective degree about each pixel of the inspected picture S. That is, a "defective degree" is acquired by the defective degree acquisition section 30 as a product (accuracy geometrical mean) of the pixel values (namely, error probability value Er) of the correspondence pixel in error probability value picture E (AB) and error probability value picture E (BC).
[0055] Drawing 10 is drawing showing typically the pixel value of each pixel of the addition picture EP acquired by doing in this way.
[0056] And the binarization processing section 41 is the processing section which carries out binarization of the pixel value (namely, integrated error probability value Er) of each pixel in the addition picture EP according to the comparison result as compared with a predetermined threshold. Thereby, the existence of the defect of the inspected object 2 in the position corresponding to each pixel of the inspect d picture S can be judged. As by specifically carrying out binarization of these values by the proper threshold shows to drawing 11 , it is outputted as an inspection result signal so that a defective pixel may be set to 1 and a normal pixel may be set to 0.
[0057] Drawing 11 is drawing showing typically the judgment result of the existence of the defect acquired by doing in this way.
[0058] Here, generally a generating position and the generating intensity of the noise contained in a signal are random, and possibility that the noise of the same position and the same intensity will occur is considered to be a low thing in each picture signal about three unit patterns PA, PB, and PC. Therefore, when the error probability value Er of error probability value picture E (AB) and error probability value picture E (BC) turns into a value with big all (i.e., when the pixel value of the addition picture EP becomes large), it is thought that the probability that the pixel is a true defect is very high. For example, about the 3rd pixel (true defect) shown in drawing 7 , since the error probability value Er of error probability value pictur E (AB) and error probability value picture E (BC) turns into a value with big all as shown in drawing 9 , as shown in drawing 10 , the pixel value of the addition picture EP which is both int grat d value also turns into a big value. Moreover, the same is said of the 11th pixel which is a tru d fect.
[0059] On the other hand, when a noise occurs to any one signal among the signals of three unit patt rns PA, PB, and PC, one of absolute value picture A (AB) and

the A (BC) serves as a small value. Therefore, it becom s a value also with comparatively small one of two error probability value picture E (AB) and the E (BC) and value in the addition picture EP searched for as a product of ach pixel of these error probability value picture E (AB) and E (BC) since it b came a small value. For example, as shown in drawing 7 , even if it is the case where the noise is contained in the signal of the 6th pixel position of the unit pattern PA Since th error probability value Er of error probability value picture E (BC) turns into a small value although the error probability value Er of error probability value picture E (AB) turns into a big value, as shown in drawing 9 , As shown in drawing 10 , both integrated value (6th value of drawing 10) in the addition picture EP turns into a comparatively small value.

[0060] Thus, by integrating two error probability values Er, the influence of a nois is reduced and it becomes possible to separate a defective pixel and a normal pix l more appropriately.

[0061] after carrying out binarization of the two error probability values Er as technology of using the information on two error probability values Er, by the threshold which is predetermined here, respectively, it is also possible to use the technology of taking those ANDs (AND) However, since binarization of the information on the gradation value (multiple value) of the multi-stage story of the rror probability value Er is carried out and the amount of information is decreasing before taking an AND when such technology is used, it cannot be said that the information is fully utilizable.

[0062] On the other hand, according to the technology of this operation gestalt, by taking the product of the error probability value Er of a multiple value in the stage before performing binarization processing, the deficit of the information by binarization is not still generated and more information can be utilized at the time of the addition. That is, this integrated value (addition picture EP) is a value acquired after fully utilizing the information on the multiple value of each error probability value Er. Therefore, since the existence of a defect can be judged based on the integrated value (addition picture EP) which fully utilized and acquir d the information on a multiple value, it is possible to detect a defective pixel in a high precision.

[0063] Furthermore, in this operation form, it is asking for the defective degree by using the product (strictly geometrical mean) of two error probability values Er which standardized the pixel value of each pixel of two difference fractionation images U using standard deviation sigma. Therefore, each pixel value of the addition picture EP can be used as an objective evaluation index in being obtained as an index standardized using standard deviation like the 1st operation form, and evaluating a defective degree. Therefore, the existence of the defect of each pixel in the inspected picture S can be more appropriately judged by asking for a size relation with the threshold defined appropriately.

[0064] Although the case wh r pattern inspection was conduct d using one or more reference pictures R to one inspected picture S was explained in <C. and others> above-mentioned each operation gestalt You may conduct d fectiv inspection of the inspected field by not being limited to this, but acquiring two or more inspected pictures S about the same inspected field in th inspected object

2, and conducting pattern inspection to two or more of these inspected pictur s S using on or more reference pictures R.
[0065] For example, what is necessary is to picturize two inspected pictures S, when it differs in time, to g nerate two difference fractionation imag s U between each of these two inspected pictures S, and one reference picture R, and just to perform the same operation as the 2nd operation gestalt to these two difference fractionation images U about the same inspected field in the inspected object 2. concrete -- each -- difference -- the standard deviation sigma about the pixel value of Picture U -- using -- being concerned -- each -- difference -- the pixel value of each pixel in Picture U -- the error probability value Er -- changing -- further -- two difference -- each pixel of the inspected picture S can acquire the degree which is a defect by asking for the product of the error probability value Er of a correspondence pixel covering Picture U The defective degree of each pixel in the inspected picture S is acquirable with a sufficient precision with this.
[0066] In addition, although the case where two inspected pictures S were acquired was explained, it may not be limited to this, but three or more inspect d pictures S may be acquired, and same operation may be performed here. moreover, the inspected picture S of these plurality -- respectively -- ** -- two or mor reference pictures R -- respectively -- ** -- difference -- two or more pictur s U may be acquired and same operation may be performed
[0067] moreover, each above-mentioned operation gestalt -- setting -- difference -- although the transform function (several 1 reference) as shown in drawing 4 was used in computing the error probability value Er from the absolute concentration value i, it is not limited to this
[0068] for example, the difference which gives the error probability value Er of values other than 0.0 and 1.0 as shown in drawing 12 -- you may change the range of the absolute concentration value i the case of drawing 12 -- the difference from a value (Cminxsigma) to a value (Cmaxxsigma) -- it has linear relation for the error probability value Er of 0.0 to 1.0 to the absolute concentration value i -- as -- matching -- the difference from 0.0 to a value (Cminxsigma) -- the absolute concentration value i -- receiving -- the difference from error probability value Er=0 and a value (Cmaxxsigma) to maximum (255) -- the case where it matches so that it may be referred to as error probability value Er=1.0 to the In this case, in the range (range near the threshold) which contributes to especially defective distinction greatly, it is convertible so that the error probability value Er may change a lot. Therefore, the error probability value Er which changes to high sensitivity [near the threshold] can be obtained.
[0069] furthermore, drawing 4 and drawing 12 -- setting -- difference -- although the case where the absolute concentration value i and the error probability value Er had linear relation was explained, it limits to this -- not having -- difference -- the absolute concentration value i and the error probability value Er may have the nonlinear relation for example, drawing 13 -- difference -- the case where the r lation b tween th absolute conc ntration value i and the error probability value Er is expressed using a sigmoid function is shown Ev n if it uses such a transform function, the above-mentioned conversion operation can be p rformed.
[0070] Moreover, although each above-mentioned operation gestalt explained the

case where the "die" was repeatedly arranged as a unit pattern on a semiconductor wafer, it is good also considering the still smaller pattern which is not limited to this but exists in the interior of a "die" as a "unit pattern." Furthermore, it is not limited to adopting a two-dimensional fi ld as a "unit pattern", but a-like 1-dimensional field may be adopted. That is, you may adopt a settlement of two or more pixels which exist on one line as a "unit pattern" (therefore, the inspected picture S or a reference picture (R)).

[0071] Furthermore, in the above-mentioned operation form, although standard deviation sigma was computed by performing statistics processing in each difference fractionation image U of every, it is not limited to this. For example, you may compute standard deviation sigma by performing statistics processing for every predetermined line in the difference fractionation image U, and every specific appointed field. In this case, since the more nearly local standard deviation sigma can be obtained, still more flexible correspondence, such as becoming possible to follow the local change in the difference fractionation image U, is attained.

[0072] Moreover, in each above-mentioned operation form, although the semiconductor wafer was illustrated as an inspected object, you may be a light filter, a shadow mask, a printed wired board, etc. that what is necessary is just th thing which is not limited to this but has a unit pattern, or the thing which has a repeat pattern.

[0073] furthermore, the above-mentioned operation gestalt -- setting -- difference -- the "standard deviation" about the pixel value of Picture U -- using -- the difference -- although the defective degree about each pixel of an inspected picture was acquired by changing the pixel value of each pixel in Picture U into an error probability value, it is also equivalent to using "standard deviation" to, use "distribution" which is the square of standard deviation for example Therefore, it shall be contained in the concept ["use / distribution"] of "using standard deviation" in this specification.

[0074]

[Effect of the Invention] as mentioned above -- according to a claim 1 or invention according to claim 5 -- the difference between a reference picture and an inspected picture -- a picture -- generating -- the difference concerned -- the standard deviation about the pixel value of a picture -- using -- the difference concerned -- the defective degree about each pixel of an inspected picture is acquirable by changing the pixel value of each pixel in a picture into an error probability value Therefore, objective evaluation can be easily performed by obtaining the index generalized using standard deviation in evaluating a defectiv degree.

[0075] According to invention according to claim 2, especially a reference picture acquisition means Two or more reference pictures are acquired. a defective degree acquisition means Two or more difference fractionation images between each of two or more reference pictures and an inspected pictur are gen rated. being concerned -- each -- difference -- the standard deviation about the pixel value of a picture -- using -- being concerned -- each -- difference -- the pix l value of each pix l in a picture -- an rror probability value -- changing -- further two or more difference -- each pixel of an inspected picture acquires the d gree which is

a defect by asking for the product of the error probability value of a correspondence pixel cov ring a picture Here, since a defective degre is acquired by using the product of the error probability value which has the value of a multi-stage story, based on more amount of information, the defectiv degr e is acquirable. Therefore, acquisition of a more exact defective degree is attained.
[0076] Moreover, according to invention according to claim 3, an inspected picture acquisition means acquires the picture about one unit pattern contained in the image pck-up picture about the inspected object which has a repeat pattern as an inspected picture, and a reference picture acquisition means acquires each pictur about two or more unit patterns other than the inspected picture included in an image pck-up picture as two or more reference pictures. Therefore, even if it is the case where a reference picture is not an ideal picture theoretically, each pix l of the aforementioned inspected picture can acquire the degree which is a def ct by asking for the product of the error probability value of a correspondence pixel covering two or more of those difference fractionation images about two or mor difference fractionation images of two or more unit patterns other than the inspected picture included in an image pck-up picture, and an inspected pictur .
[0077] According to invention according to claim 4, furthermore, an inspected picture acquisition means Two or more inspected pictures about the same inspected field are acquired. a defective degree acquisition means Two or more difference fractionation images between each of two or more inspected pictur s and the aforementioned reference picture are generated. being concerned -- each -- difference -- the standard deviation about the pixel value of a picture -- using -- being concerned -- each -- difference -- the pixel value of each pixel in a picture -- an error probability value -- changing -- the difference of further the aforementioned plurality -- by asking for the product of the error probability value of a correspondence pixel covering a picture Each pixel of the aforementioned inspected picture can acquire the degree which is a defect. Therefore, each pixel of two or more inspected pictures related with the same inspected field can acquire the degree which is a defect with a sufficient precision.
[0078] Moreover, according to invention according to claim 5, since a judgment means judges the existence of a defect based on the size relation between the defective degree obtained by the defective degree acquisition means, and a predetermined threshold, it can judge the existence of the defect of an inspect d object with a sufficient precision.

[Translation done.]

DESCRIPTION OF DRAWINGS

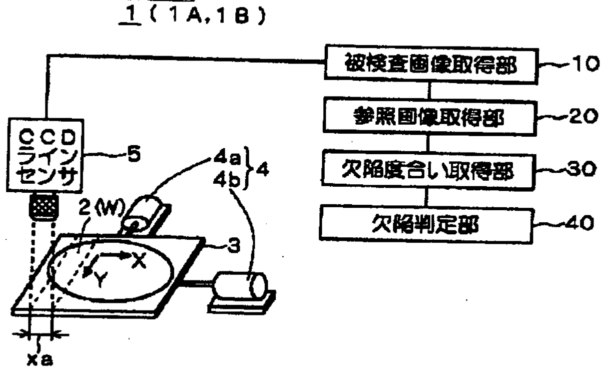
[Brief Description of the Drawings]
[Drawing 1] It is a schematic diagram showing the composition of pattern test equipment 1A concerning the 1st operation gestalt of this invention.
[Drawing 2] It is a plan showing the detail of the semiconductor wafer W.
[Drawing 3] It is the functional block diagram of the defective degree acquisition section 30 and the defective judging section 40.
[Drawing 4] difference -- it is drawing showing the transform function which performs conversion to the error probability value Er from the absolute concentration value i
[Drawing 5] It is drawing showing the pixel distribution about two or more pixels contained in the difference fractionation image U.
[Drawing 6] It is the functional block diagram of the defective degree acquisition section 30 (30B) concerning the 2nd operation gestalt, and the defective judging section 40 (40B).
[Drawing 7] It is drawing having shown typically the pixel value of each pixel about the unit patterns PA, PB, and PC.
[Drawing 8] It is drawing showing typically the pixel value of each pixel of the absolute value picture A.
[Drawing 9] It is drawing showing typically the pixel value of each pixel of the error probability value picture E.
[Drawing 10] It is drawing showing typically the pixel value of each pixel of the addition picture EP.
[Drawing 11] It is drawing showing the judgment result of the existence of a defect typically.
[Drawing 12] It is drawing showing another transform function.
[Drawing 13] It is drawing showing still more nearly another transform function.
[Drawing 14] It is drawing for explaining the conventional technology.
[Description of Notations]
1, 1A, 1B Pattern test equipment
2 Inspected Object
2a Die
3 X-Y Table
5 CCD Line Sensor
A Absolute value picture

EP, an addition picture
PA, PB, PC Unit pattern
R Reference picture
S Inspected picture
U Difference fractionation image
W Semiconductor wafer
sigma Standard deviation

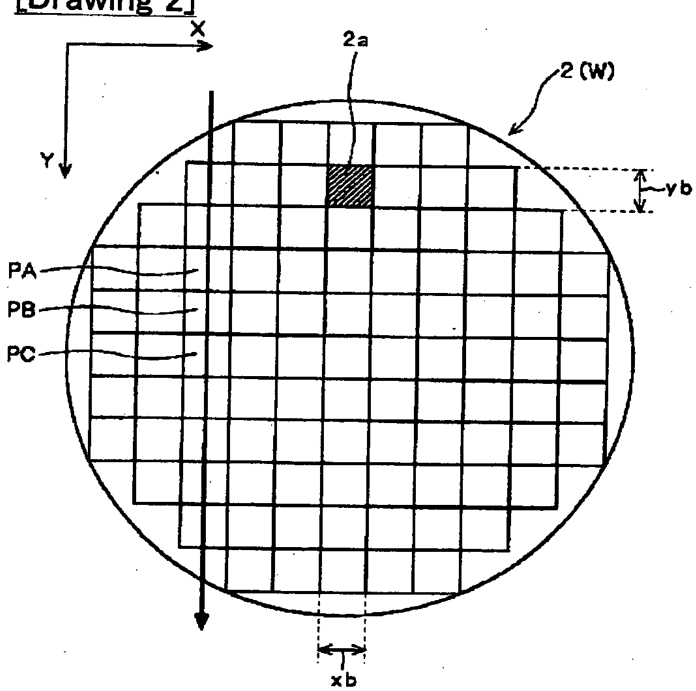
[Translation done.]

DRAWINGS

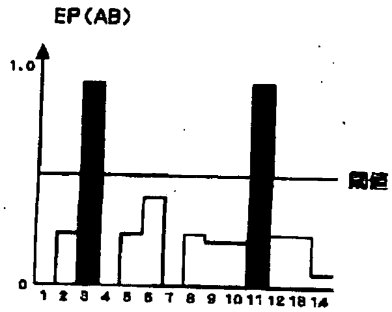
[Drawing 1]



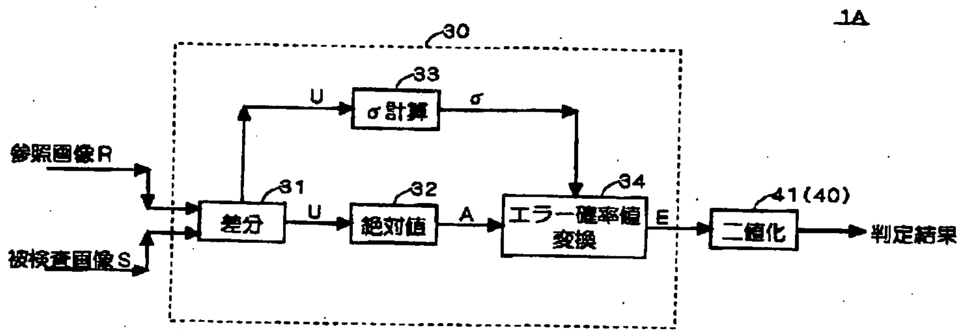
[Drawing 2]



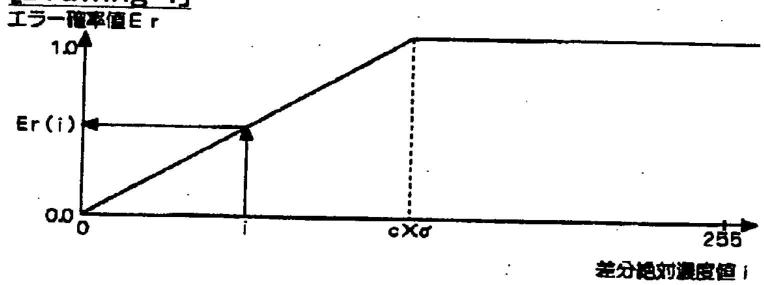
[Drawing 10]



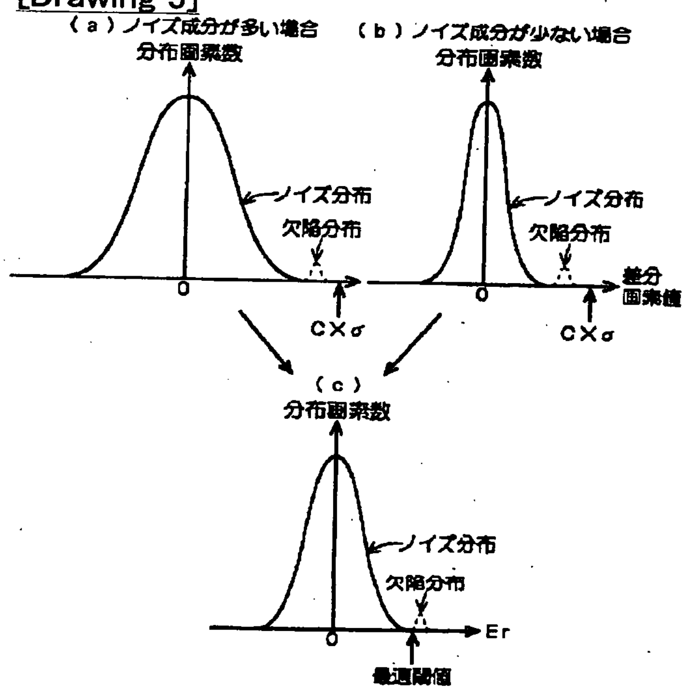
[Drawing 3]



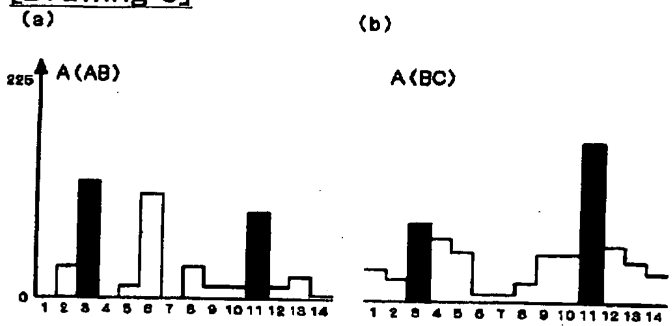
[Drawing 4]



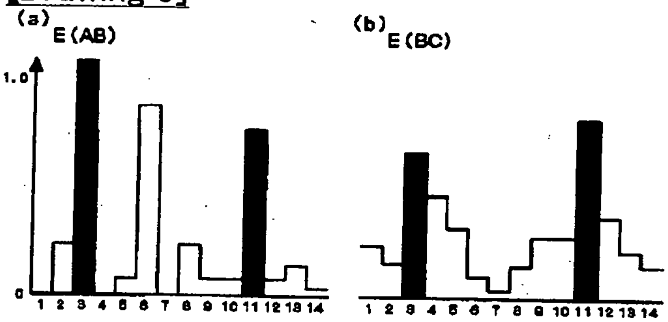
[Drawing 5]



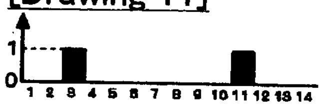
[Drawing 8]



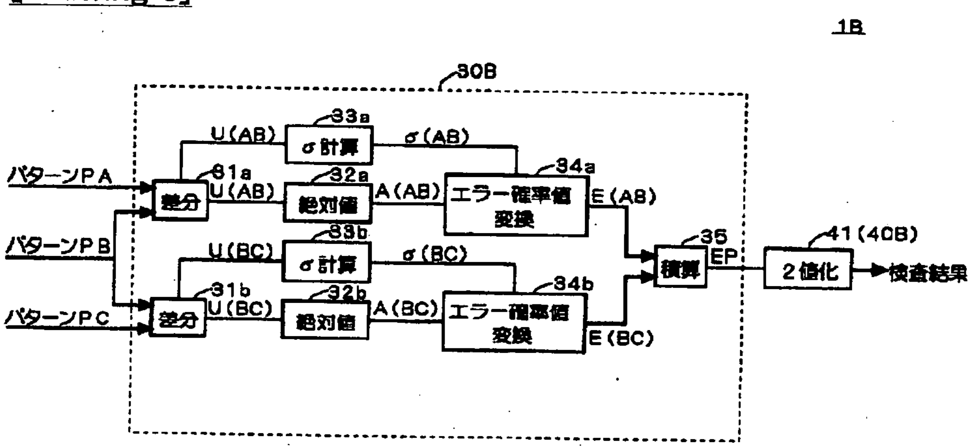
[Drawing 9]



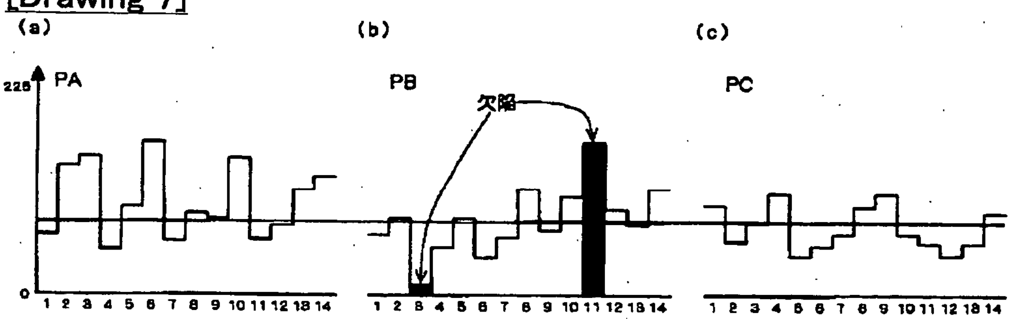
[Drawing 11]



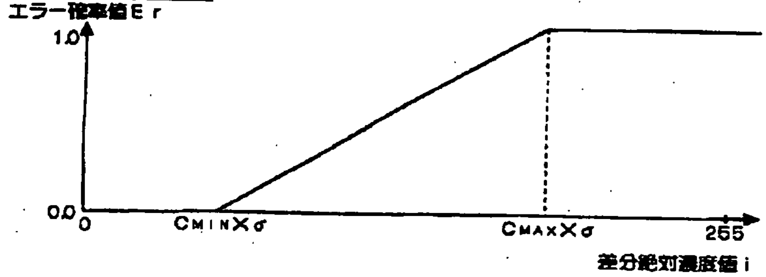
[Drawing 6]



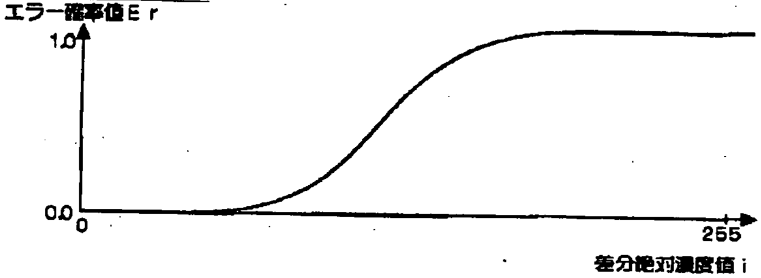
[Drawing 7]



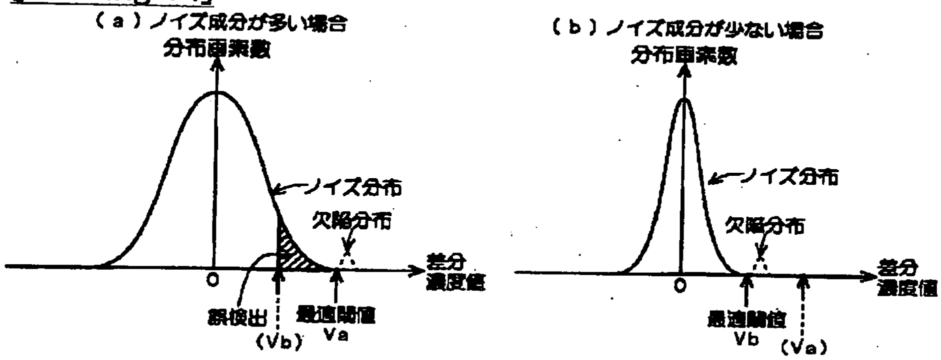
[Drawing 12]



[Drawing 13]



[Drawing 14]



[Translation done.]